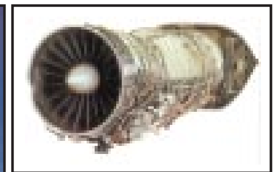
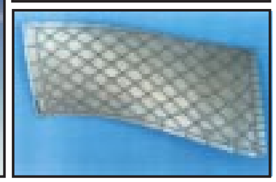
Ultra-Thin Nickel-Base Structural Casting Improves Aircraft Engine Performance





Payoff

Ultra-thin cast nickel-base structural castings is a critical technology that will help reduce engine cost and weight, improve thrust-to-weight ratio, increase durability and improve range. This technology will enable vital modifications to existing Air Force and Navy weapon systems where lightweight components are required. Ultra-thin cast nickel-base technology is capable of manufacturing 100-percent retrofitable components and is applicable to castings on commercial engines. This development results in a $40,000 per-engine cost avoidance, which translates into a $24 million dollar cost avoidance for a 600-engine production buy.

Accomplishment

Scientists and engineers from the Air Force Research Laboratory's (AFRL's) Materials and Manufacturing Directorate (ML) contracted with United Technologies Corporation to develop a program for using advanced materials processing technology in the manufacture of propulsion and structural components. Their primary objective was to develop cost-effective manufacturing processes capable of producing ultra-thin (20-30 mils), cast components to reduce engine weight, improve thrust-to-weight ratio, increase durability and improve range. These processes would also allow modifications to existing Air Force and Navy weapon systems, where lightweight components are required, and would provide the capability of manufacturing 100-percent retrofitable components.

Background

Many aircraft turbine engine cast components are manufactured thicker than required by structural design and analysis because state-of-the-art casting techniques are limited to 0.060-0.070 inch minimum thickness. Continued improvements in gas turbine technology could lead to the development of lower weight structural components with higher metal temperature capability. The feasibility of casting small-scale ultra-thin structures in the range of 0.020-0.030 inch thickness has been demonstrated; however, the need still exists to exploit this technology for the cost-effective fabrication of reproducible and reliable large geometrically complex components. Several processes have been used to demonstrate the capability to cast thin-wall nickel-base alloys but the optimum process has not been identified. The work to date has been limited to small-medium sub-element size pieces. Research scientists and engineers at United Technologies Corporation, under contract with ML, developed a program aimed at applying advanced materials processing technology to the manufacture of propulsion and structural components. During Phase I, a casting supplier and material was selected and a sub-element configuration designed for casting process development trials. In Phase II, a larger size sub-component, based on the Phase I results, was designed. The selected casting process is being optimized and employed to cast sub-components for laboratory and engine testing on the Component and Engine Structural Assessment Research (CAESAR) engine. Following engine tests on CAESAR, the sub-components are being evaluated and a cost analysis provided for producing a full-scale component. Finally, a preliminary assessment of applicable repair methods for the cast sub-component will be identified based on engine test experience and selected repair methods.